Claims

What we claim is:

1. Crystallization method for forming crystals of a substance in a solution, a suspension, or a mixture of liquids, in particular ice crystals from an aqueous solution or organic crystals from an organic melt, the method comprising the steps of:

- crystallizing the solution to form a crystal slurry by means of cooling in a heat exchanger;

- feeding the crystal slurry from an outflow side of the heat exchanger to an inflow side of the heat exchanger via a recirculation duct and separating at least a part of the crystals from the liquid, characterized in that a recirculation pump is included in the recirculation duct wherein the slurry is continuously supplied through the recirculation duct such that the crystals are homogeneously distributed in the duct and the heat exchanger and such that the under cooling at the outlet of the heat exchanger is the equilibrium temperature T_{eq} minus 0.5 to 0.9 times the meta-stable region ΔT_{max}.

2. Crystallization method according to claim 1, wherein no filter or separator is included in a recirculation path between the outlet of the heat exchanger and the inlet of the heat exchanger.

3. Crystallization method according to claim 1 or 2, wherein a scraped surface heat exchanger is used for supply of the cooling characterized in that the suspension is passed through a space between a heat exchanging wall and an inner rotor for support of a scraper means, the distance between the inner rotor and the wall being larger than 10 mm, preferably larger than 15 mm and most preferably being between 0.1 and 0.4 times an outer diameter of the heat exchanger.

4. Crystallization method according to claim 3, wherein and the specific heat flux through the heat exchanger wall is limited to a value below 40,000 W/m^2, preferably below 30,000 W/m^2, and the specific mass flow rate in the recirculation duct per kilogram of crystallized substance is about 8 to 50 times the reciprocal of the meta-stable region and preferably about 17 to 25 times the reciprocal of the meta-stable region.

5. Crystallization method according to claim 1 or 2, wherein a shell and tube heat exchanger is used for supply of the cooling, comprising a number of tubes, wherein the flow rate of the suspension in the tubes is between 1.5 m/s and 3 m/s, and preferably between 1.8 m/s and 2 m/s, the specific heat flux through the heat exchanger wall being limited to a value below 1000 W/m^2 and more preferably below 500 W/m^2 and also characterized in that the specific mass flow rate in the recirculation duct per kilogram of crystallized substance is about 50 to 300 times the reciprocal of the meta-stable region and preferably about 100 to 150 times the reciprocal of the meta-stable region.

6. Crystallization method according to any of claims 1 to 5, wherein a diameter of the recirculation duct is between 100 mm and 2000 mm, the length is between 10 m and 100 m and preferably between 15 m and 30 m such as to reduce the under cooling of the suspension before the inlet of the heat exchanger to a value of between 0 and 0.3 times the meta-stable region. .

7. Crystallization method according to claim 6, wherein the flow speed in the recirculation duct is between 0.2 m/s and 3 m/s and preferably between 0.5 m/s and 1.5 m/s.

8. Crystallization method according to any of the preceeding claims, wherein the crystal concentration is between 10 wt% and 40 wt% and preferably between 25 wt% and 30 wt%.

9. Crystallization method according to any of the preceeding claims, wherein the recirculation pump comprises an impeller which is run at a tip speed of below 15 m/s and preferably below 12 m/s.

10. Crystallization method according to any of the preceeding claims, wherein the crystal slurry is supplied to a wash column, preferably a piston type or a screw type wash column and most preferably a piston type wash column.

11. Crystallizer assembly comprising a heat exchanger with an inlet and an outlet for forming a crystal slurry, a recirculation duct connected between the inlet and the outlet for recirculation of the crystal slurry, formed in the heat exchanger from the outlet to the inlet and a separator connected to the heat exchanger for separating crystals from the slurry, wherein no filter or separator is included in a recirculation path between the outlet of the heat exchanger and the inlet of the heat exchanger.

12. Crystallizer assembly according to claim 11, comprising a scraped surface heat exchanger (SSHE) having an outlet and an inlet, and a recirculation duct connecting the outlet to the inlet, characterized in that a recirculation pump is connected to the recirculation duct, wherein the SSHE comprises a generally cylindrical vessel having a predetermined diameter and an internal scraping means mounted on a rotor, rotatable around a central axis of the heat exchanger, wherein a distance between the rotor and a wall of the crystallizer is between 0,1 and 0,4 times the diameter of the heat exchanger, preferably at least 15 mm..

13. Crystallizer assembly according to claims 11 or 12, wherein the outlet of the heat exchanger is shaped such that the transition of the outflow from the scraped surface heat exchanger into the recirculation duct is gradual such as to maintain a relatively constant suspension velocity or preferably an increasing velocity towards the outflow of the scraped surface heat exchanger.

14. Crystallizer according to any of claims 11-13, wherein a diameter of the recirculation duct is between 100 mm and 2000 mm, the length is between 10 m and 100 m and preferably between 15 m and 30 m such as to reduce the under cooling of the suspension before the inlet of the heat exchanger to a value of between 0 and 0.3 times the meta-stable region.

15. Crystallizer assembly according to claim 11, comprising a shell and tube heat exchanger (S&T HE), wherein the shell and tube heat exchanger comprises a bundle of individual tubes each with an inner diameter of above 25 mm and preferably above 36 mm.